Citation:

Savage JS, Marini M, Birch LL. Dietary energy density predicts women's weight change over 6 y. *Am J Clin Nutr.* 2008 Sep; 88(3):677-84.

PubMed ID: 18779283

Study Design:

Prospective cohort study

Class:

B - Click here for explanation of classification scheme.

Research Design and Implementation Rating:

POSITIVE: See Research Design and Implementation Criteria Checklist below.

Research Purpose:

- Main purpose: to examine the relation of energy density (ED) to weight change over time among free-living women, with the use of longitudinal data
- Secondary aim: to describe differences in patterns of dietary intake among women with diets differing in ED, including information on food group intake, meal frequency, and the contexts in which eating occurred at study entry

Inclusion Criteria:

- Non-Hispanic white women living in central Pennsylvania recruited as part of a longitudinal study designed to examine parental influences on girls' growth and development.
- Eligibility criteria focused on the daughters' characteristics, including the absence of severe food allergies or chronic medical problems affecting food intake and the absence of dietary restrictions involving animal products.
- There were no exclusion criteria for mothers. Only data for mothers are considered in this study.

Exclusion Criteria:

None specifically mentioned.

Description of Study Protocol:

Recruitment

- Families with age-eligible female children within a 5-county radius were identified with the use of available marketing information (Metromail Inc, Chicago, IL).
- These families received mailings that provided information about the study and were recruited with the use of follow-up phone calls.

Design: Prospective cohort study

Blinding used (if applicable): not applicable

Intervention (if applicable): not applicable

Statistical Analysis

For the primary analyses of interest, a mixed-modeling approach (PROC MIXED) was used.

Data Collection Summary:

Timing of Measurements

At study entry, year 2, year 4, and year 6.

Dependent Variables

- Weight or BMI change over time: Height and weight measurements were assessed in triplicate at each follow-up occasion by a trained staff member
- Overweight: BMI≥25

Independent Variables

- Energy density (ED, in kcal/g)): 24-hr diet recall interviews were conducted by telephone at the Dietary Assessment Center at the Pennsylvania State University at each occasion by trained staff with the use of the computer-assisted NUTRITION DATA SYSTEM FOR RESEARCH (NDS-R) software (database version 4.01_30; Nutrition Coordinating Center, University of Minnesota, Minneapolis,MN). ED was calculated from the three 24-h recalls, with the use of energy content of all foods, excluding all beverages, for each subject at all 4 time points.To calculate ED, energy and gram intakes for each eating occasion were summed for each of the 3 d. Next, total energy intake from the food consumed for each of the 3 d was divided by the total weight of food consumed for each of the 3 d. For each participant, a mean ED value was derived by taking the average of the 3 daily ED values at the 4 time points.

Control Variables

- Main effects of time, ED, and an ED-by-time interaction were tested before (model 1) and after adjusting for initial BMI, dietary fiber intake, and caloric beverage intake (model 2). For model 3, the main effect of BMI classification [normal weight (BMI <25) compared with overweight and obese, the interaction between BMI classification, ED, and time, and all lower order (2-factor) interactions were considered. Finally, for the models predicting BMI change over time, an unstructured covariance matrix provided the best fitting model; similar predictors were tested before (model 4) and after (model 5) adjusting for initial weight status.

Description of Actual Data Sample:

Initial N: 192 (100% women)

Attrition (final N): 88% (At study entry, participants included 192 women, of whom 183, 177,

and 168 women were reassessed at year 2, year 4, and year 6, respectively). N=186 subjects with body weighty data collected at years 2-6.

Age: 35.7 ± 4.7 years

Ethnicity: non-Hispanic White

Other relevant demographics: generally well educated with a mean of 14.6 ± 2.2 years of education and middle-class family income

Anthropometrics: The sample was, on average, slightly overweight (BMI: 27.0 ± 6.2). Of the 183 participants, 105 (57%) were classified as overweight (BMI≥25) at baseline

Location: United States

Summary of Results:

Longitudinal analyses: repeated-measures mixed-effect models - Association of ED with body weight and weight gain over time

On average, women gained weight across the 6-y period (3.73 ±7.8 kg).

In model 1, the predictive model for body weight (in kg), results of the mixed-model analyses showed a significant main effect of time (P<0.001), indicating a general trend for women to gain weight over time. A significant main effect of ED (P< 0.05) was observed such that women with higher ED had higher weight at all time points. Finally, a significant interaction between ED and time was evident (P < 0.01). Therefore, a woman's pattern of weight gain depended on ED group membership. For example, women consuming higher ED diets (ED ≥1.85 kcal/g), on average, gained 6.4±6.5 kg over 6 y, whereas women consuming lower ED diets (ED ≤1.5 kcal/g) only gained 2.5 ± 6.8 kg. Women consuming intermediate-ED diets (ED: 1.5–1.85 kcal/g) gained 4.8 ±9.2 kg.

Model 2 was also tested, including dietary fiber and caloric beverage intake as covariates. Although dietary fiber and caloric beverage intakes were not significant predictors of weight change, similar results emerged for ED (data not shown). Therefore, ED predicts weight change over and above the effect of consuming diets differing in fiber and caloric beverage intakes.

In model 3, we tested a 3-factor interaction (after including all relevant main effects and 2-factor interactions) to examine whether the association between ED and time would vary across normal and overweight women (BMI classification). However, the 3-factor interaction was not significant, indicating no effect of BMI classification on the effect of ED on weight change.Therefore, the model was reduced to only consider the 2-factor interactions and main effects. A significant interaction was observed between BMI classification and time such that overweight women increased in weight at a greater rate over time than did normal-weight women (P<0.001). In addition, a significant interaction was identified between ED and time (P<0.01); as ED increased, weight increased over time. Finally, no significant interaction was observed between ED and BMI classification. Therefore, the association between ED and weight did not vary by BMI classification.

Longitudinal analyses: repeated-measures mixed-effect models - Association of ED with BMI and BMI change over time

In model 4, when the predictive model for BMI was considered, results showed a significant main effect of time ($P<0.001$) and ED ($P<0.05$). A significant interaction between ED and time was also evident ($P<0.01$). Thus, a women's pattern of BMI change over time depended on the ED group. For example, BMI increased 2.5 units among women consuming higher ED diets, whereas BMI only increased 0.9 units over 6 y for women reporting lower ED diets. Similar results emerged after adjusting for initial BMI (model 5). In addition, when including BMI classification in the model, results were in agreement with model 2, predicting weight gain (in kg) (data not shown).

Author Conclusion:

Our findings provide evidence that dietary ED is positively associated with weight gain over time among freeliving
women over a 6-y period, showing that diets lower in ED can moderate weight gain among normal-weight and overweight women.

However, our findings showed that even women who were consuming lower ED diets were not generally successful in maintaining weight at initial values across the 6-y period or in meeting the recommendations of the Dietary Guidelines for Americans for the number of daily servings of fruit and vegetables, suggesting the need for additional dietary guidance focused on providing effective strategies for reducing dietary ED.

Reviewer Comments:

Research Design and Implementation Criteria Checklist: Primary Research

Relevance Questions		
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (Not Applicable for some epidemiological studies)	Yes
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to nutrition or dietetics practice?	Yes
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes

Validity Questions		
1.	**Was the research question clearly stated?**	Yes
1.1.	Was (were) the specific intervention(s) or procedure(s) [independent variable(s)] identified?	Yes

1.2.	Was (were) the outcome(s) [dependent variable(s)] clearly indicated?	Yes
1.3.	Were the target population and setting specified?	Yes
2.	**Was the selection of study subjects/patients free from bias?**	Yes
2.1.	Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?	Yes
2.2.	Were criteria applied equally to all study groups?	Yes
2.3.	Were health, demographics, and other characteristics of subjects described?	Yes
2.4.	Were the subjects/patients a representative sample of the relevant population?	Yes
3.	**Were study groups comparable?**	Yes
3.1.	Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)	N/A
3.2.	Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?	Yes
3.3.	Were concurrent controls used? (Concurrent preferred over historical controls.)	Yes
3.4.	If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?	Yes
3.5.	If case control or cross-sectional study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)	N/A
3.6.	If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?	N/A
4.	**Was method of handling withdrawals described?**	Yes
4.1.	Were follow-up methods described and the same for all groups?	Yes
4.2.	Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)	Yes
4.3.	Were all enrolled subjects/patients (in the original sample) accounted for?	Yes
4.4.	Were reasons for withdrawals similar across groups?	Yes

4.5.	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	N/A
5.	**Was blinding used to prevent introduction of bias?**	Yes
5.1.	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	N/A
5.2.	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	N/A
5.3.	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	Yes
5.4.	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	N/A
5.5.	In diagnostic study, were test results blinded to patient history and other test results?	N/A
6.	**Were intervention/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were interveningfactors described?**	Yes
6.1.	In RCT or other intervention trial, were protocols described for all regimens studied?	N/A
6.2.	In observational study, were interventions, study settings, and clinicians/provider described?	Yes
6.3.	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	Yes
6.4.	Was the amount of exposure and, if relevant, subject/patient compliance measured?	Yes
6.5.	Were co-interventions (e.g., ancillary treatments, other therapies) described?	N/A
6.6.	Were extra or unplanned treatments described?	N/A
6.7.	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	N/A
6.8.	In diagnostic study, were details of test administration and replication sufficient?	N/A
7.	**Were outcomes clearly defined and the measurements valid and reliable?**	Yes
7.1.	Were primary and secondary endpoints described and relevant to the question?	Yes
7.2.	Were nutrition measures appropriate to question and outcomes of concern?	Yes
7.3.	Was the period of follow-up long enough for important outcome(s) to occur?	Yes
7.4.	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	Yes

7.5.	Was the measurement of effect at an appropriate level of precision?	Yes
7.6.	Were other factors accounted for (measured) that could affect outcomes?	Yes
7.7.	Were the measurements conducted consistently across groups?	Yes
8.	**Was the statistical analysis appropriate for the study design and type of outcome indicators?**	Yes
8.1.	Were statistical analyses adequately described and the results reported appropriately?	Yes
8.2.	Were correct statistical tests used and assumptions of test not violated?	Yes
8.3.	Were statistics reported with levels of significance and/or confidence intervals?	Yes
8.4.	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	N/A
8.5.	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	Yes
8.6.	Was clinical significance as well as statistical significance reported?	Yes
8.7.	If negative findings, was a power calculation reported to address type 2 error?	N/A
9.	**Are conclusions supported by results with biases and limitations taken into consideration?**	Yes
9.1.	Is there a discussion of findings?	Yes
9.2.	Are biases and study limitations identified and discussed?	Yes
10.	**Is bias due to study's funding or sponsorship unlikely?**	Yes
10.1.	Were sources of funding and investigators' affiliations described?	Yes
10.2.	Was the study free from apparent conflict of interest?	Yes